

Challenges of the Electric Vehicle Markets in Emerging Economies

Ferenc Meszaros^{1*}, Mohamad Shatanawi¹, Gabriel Ayobami Ogunkunbi¹

¹ Department of Transport Technology and Economics, Faculty of Transportation Engineering and Vehicle Engineering, Budapest University of Technology and Economics, H-1111 Budapest, Műegyetem rkp. 3., Hungary

* Corresponding author, e-mail: fmeszaros@mail.bme.hu

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Abstract

Electric mobility is an emerging market around the world. Electric vehicles have remarkable environmental gains compared to conventional vehicles, they contribute to decreasing fossil energy dependence, but they need huge investments in charging infrastructure and their market price is much above regular ones. The conditions for market penetration are generally critical in emerging economies, where the purchasing power is far below that of developed economies. In addition, further technical and regulatory barriers hinder the market uptake and augmentation. This paper aims to discover and analyze the current market conditions of electric vehicles in selected emerging economies and to set up augmentation pathways, based on experiences in developed and in developing countries.

Keywords

electric vehicles, electric mobility, charging infrastructure

1 Introduction

The lacking fossil energy sources, the environmental impacts and the rising facts of climate change are part of our life. Transportation acts a double role (Szendrő et al., 2014): it contributes to these facts as well as it suffers from the effects and impacts. Fuel combustion from transport operations are responsible for about 40 % of global CO₂ emission and climate change and leads directly (e.g. damages) and indirectly (e.g. rethink of planning considerations) to reasonable rise in transportation infrastructure expenditures.

One of the promising solutions (Domanovszky, 2014; Mikosova et al., 2018; Zöldy, 2011) for these problems is decoupling the mobility needs and the fossil energy needs. Electric mobility offers notable benefits to this process (Zöldy and Török, 2015; Smit et al., 2018), a growing share of electric vehicles (EVs) also underlines its potentials, see thriving examples of China, Norway, Japan, Germany and USA. In 2017 the global stock of electric vehicles exceeded the 3 million limit and global sales increased by 54 %, but the future is even prosperous: 13 million vehicles are expected by 2020 and between 130 million and 228 million vehicles by 2030 (IEA, 2018a). Increasing demand, therefore, leads to intensive technology developments and growing electric car manufacture capabilities.

In most cases market expansion is derived from policy measures (Lieven, 2015) and market incentives from the state (Brady and O'Mahony, 2011; Hall and Lutsey, 2017), as EVs – besides environmental and energy efficiency gains – are more expensive, they have less efficient range, more time is needed for charging them and the available charging network is remarkably less than in case of conventional vehicles (Zöldy et al., 2013). Additionally, battery technology generally requires rare earth elements, which makes it less accessible for low and middle income countries. Therefore, research, development and innovation processes investigate alternative solutions to the standard lithium-ion batteries (Cano et al., 2018).

A general but not self-evident condition for electric vehicle penetration is the availability of electricity grids and charging points (Csiszar et al., 2017; Papp and Torok, 2018). Many countries around the world have problems with reliable and sufficient electricity production and transmission, moreover, energy prices can vary significantly (Meszaros and Andrejszki, 2014).

Consequently, procurement of electric vehicles and the development of charging infrastructure are costly elements, moreover, there are different types of consumer

behavior affected by several factors (Rezvani et al., 2015; Mikusova et al., 2018). These could lead to further constraints in countries with lower purchasing power and lacking financial sources.

The authors focus on the general and specific characteristics of electric mobility, and market uptake conditions. The article details the current market conditions and the available incentives for electric vehicles. The research aims to discover the market conditions and potentials of emerging economies and to outline possible augmentation pathways. Emerging economies are grouped by geographical areas, to explore and identify regional specialities.

2 Methodology

The EV market is a worldwide developing mobility area, but due to economic, social and political differences, each country or region has a different approach in boosting the EV market. First, a general overview of the EV market (fleets, charging infrastructure, strategies, scenarios) gives the readers an insight into emerging economies. Due to being in the initial phase, the preconditions for augmentation are discovered (stakeholders, business models, private investment potentials), after which the required factors for wide implementation (regulators, operators, users, initiatives) are stated. Finally, the authors conclude with the challenges of expansion, and derive possible pathways for the future, based on existing experience.

Input for the analysis is carried out through a guided survey among Master of Science international students studying transportation engineering in the Hungarian higher education. Their knowledge about local facts and plans are highly considered and welcome in this research.

3 Market conditions and potentials

3.1 Middle East

3.1.1 Jordan

The use of EVs is increasing in Jordan, due to the low operational cost as well as the maintenance cost compared to vehicles with conventionally fueled vehicles. On the other hand, the government supports the EV sector by exempting it from registration fees, in order to reduce the cost of fuel invoice and improve the environment. Although a contradictory step was taken at the beginning of 2019 as the customs fee was increased to 25 %. This increment has raised the cost of EVs, affecting the EV market in Jordan negatively. The main factor discouraging users from purchasing EVs prior to this has been the lack of charging stations in the kingdom. However, the government approved

an agreement with the eCharge company in 2018 to install 10000 smart charging station across the kingdom with fast charging capabilities. Likewise, the government enacted a law aiming not to authorize a new gas station to operate except it offers charging service for EV user.

The first charging station in Jordan started operations in 2014, since then the number of electric vehicles and charging stations has been on the rise as shown in Table 1. Many plans and projects are in the pipeline to expand this trend among the citizens and facilitate EV ownership. The private sector is also involved in this venture. For example, some companies offer to install charging units in private residences. Likewise, the public transport companies are starting to consider the use of EVs. For instance, Taxi Moumayaz Company started using EVs as a taxi in 2015 under the logo "Tawseelah". The interest in EVs comes from the highest level in Jordan as the Royal palace added 200 EVs to the existing fleet in 2016 as well as the EVs are used nowadays by the Prime Minister, the Senate President, the Parliament Chairman, and many top-ranked officers in the government.

The congestion level in the capital city of Jordan (Amman) is considered critical, with a high share of the private vehicles and a low share of public transport and soft mobility options (Shatanawi et al., 2018). Considering this with the political and public will in using the EVs, it would be a successful project if the required infrastructure is installed properly.

3.1.2 Turkey

Only 77 EVs were sold in the Turkish market in 2017, however, the turnout in using electric vehicles can be seen in the huge increment in buying the hybrid cars, with 4451 hybrid cars sold in the market in d same year. The reason behind changing the trend towards EVs can be the governmental policies which aim to encourage the citizens to move towards using EVs where the special consumption tax regulation was adopted in 2016 to reduce the tax on the EVs according to the electrical motor power capacity ranging from 3 %–15 %. Likewise, the government supports research centers studying and developing electric vehicles such as Tübitak Mrc Energy Institute by connecting these centers to the industrial market (IEA, 2018b).

Table 1 No. of EVs and charging stations (Source: Khalaileh, 2017)

Year	2014	2015	2016	1/1/2017-1/6/2017
Registered EVs No.	9	345	1230	3488
Charging stations No.	1	1-10	10	15

Moreover, a joint venture of Turkish companies is working on manufacturing the first Turkish-made electric car since November 2017 where the prototype is expected to be presented in 2019 and the massive production to start by the end of 2021.

The first EV rapid charging station was opened on October 30, 2017, at Aytemiz petrol station. The station is capable of charging two vehicles at the same time within 25 minutes. Since then the petrol stations started to install charging facilities in Turkish cities. For example, Zorlu energy group was to install 25 charging stations in 2018, aiming to reach 250 charging stations by the end of 2019 with the capacity of charging four vehicles simultaneously within 45 minutes. Side by side, the government supports establishing the EV charging stations by exempting the providers from licensing the charging stations, this regulation was adopted as the government wants the providers to get fees for providing a service, and not for profit.

The share of EVs in Turkey is still small but developing quickly, especially with the expectation to release the first Turkish-made electric car soon and encouragement of the government for using the EVs. The demand for EVs is growing higher and with this realization, the private sector is gearing to adapt to the change in demand. However, the main difficulties in adopting the EVs in Turkey is the people's perception of electrically powered vehicles, they are hesitant to use such model, especially with the lack in charging infrastructure at the time being and the apprehension of changing from conventional cars.

3.1.3 Syria

There is neither a remarkable number of EVs nor charging stations in Syria. The government allowed importing EVs in 2010 and before that, it was prohibited to use electric cars in the country. However, the promotion of the concept of EVs can be seen by the two prototypes which were made in 2007, one of them is under development in Damascus University, while the other was a privately engineered prototype (Almasri et al., 2011). Likewise, the Iranian-Syrian company for producing cars "Siamco" moved to manufacture both EVs and hybrid vehicles along with the conventional vehicles since 2016.

Less than a year after the lift of the ban in using EVs in Syria, the war started which left no place for developing the infrastructure or promoting the concept of EVs.

3.1.4 Lebanon

The Lebanese suffer from the inconsistent supply of electricity, where the government is not able to solve this problem and provide electricity regularly on a 24/7 basis to the citizens. The Automobile Importer advisor mentioned that Lebanon is far from fulfilling the EVs program. The reasons behind such view could be referred to the late government incentives to promote EVs, where the Lebanese government approved a regulation that decreases the customs fee on EVs to zero and on Hybrid vehicles to 20 % on 18 Apr 2018, before that the EVs were more expensive than fuel-based vehicles. Likewise, the lack of required infrastructure for EVs, for instance, the charging stations. Not to forget, the main barrier is the poor supply of electricity which is mentioned above.

The first charging station was opened by Medco -Lebanese importer and distributor of refined petroleum products- in four locations in Beirut, June 2018 which can charge different brands of EVs within 20 minutes. The emission level in Lebanon is very high where the emission of CO₂ ranges between 351-2000 parts per million (ppm) where the European standard does not allow more than 10 ppm. That's why Lebanon needs to change the travel behavior as well as the used transport mode and switch to eco-friendly cars. However, this will be difficult considering the mentioned problems and obstacles mentioned above, adding to it that many Lebanese live in apartments which complicate the charging of the vehicle, the heavy traffic and congestion in the cities which consume more energy. Lastly, the absence of the real political will to promote the EVs.

3.2 Far East

3.2.1 Kazakhstan

For a country with a vibrant automobile industry coupled with high demand for vehicle ownership, a huge share of EV will be expected in the country's fleet of vehicles. Contrastingly, according to Union of Automotive Enterprises of Kazakhstan, only 36 electric vehicles were registered in the year 2017 out of 69,900 newly registered vehicles and the total number of EVs within the country has been estimated to be about 200. The low share has been attributed to the cost of electric vehicles being higher than conventionally fueled vehicles coupled with the unavailability of ready-to-use charging infrastructure across the cities, natural barriers as the average level of income, the harsh climate, low population density and distance.

However, with traffic-related air pollution on the rise in Almaty (Carlsen et al., 2013) and likely in other cities of

the country, the government has been spurred to enable a modal shift towards green cars by investing in the provision of charging stations across the country while encouraging the local production of EVs by Kazakh automakers. Negotiations are also being made with the energy retail companies towards a reduction in the unit cost of electricity supply for public charging stations. Notwithstanding these, to achieve a rapid uptake of EVs, the government needs to provide subsidies on vehicle registration costs as well as revert to the zero customs duties that was once given to the energy friendly cars.

3.2.2 Azerbaijan

Although there is no official figure for the number of electric vehicles or charging infrastructure in use within Azerbaijan, EVs are gradually becoming common in the country due to favorable government strategy. In line with its commitment to promoting the use of electric vehicles as stated in the country's Nationally Determined Contribution to the United Nation's Framework Convention on Climate Change (UNFCCC, 2017), the government has waived customs duties and other taxes on the import of electric vehicles. This together with the efforts of automotive dealers, in advocacy for the use of EVs and installation of charging points, was responsible for the 101 EVs added to the fleet of vehicles in 2018 as reported by the State Customs Committee. However, much is left to be desired as most of these strides are recorded in the capital city of Baku only.

3.2.3 Pakistan

Due to supportive government policy, the Pakistan auto market has gained investments from foreign automobile brands which have led to a remarkable increase in the number of vehicles, including electric vehicles. For example, the 2018 budget lowered the customs duty to 25 % and gave a 16 % waiver in the regulatory duty on electric vehicles. Unfortunately, electricity shortfall, driving range concerns because of inadequate charging infrastructure are foremost factors still limiting the wide adoption of EVs in the country. However, according to a study carried out by the LUMS Energy Institute and the US-Pakistan Centre for Advanced Studies in Energy (Arshad et al., 2019), new power generation efforts undertaken by the National Transmission and Dispatch Company promises an end to the electricity shortfall in the country. The government together with automobile manufacturers and private investors will thus be left

with the task of addressing the infrastructural deficit by installing charging stations at a strategic location for use at low cost while sensitizing the populace on the benefits of adopting EV use especially as it will aid the reduction of the air pollution in the country.

3.2.4 Mongolia

Concerted efforts are being made to increase the modal share of electric vehicles in the Mongolian fleet of vehicles by the government and the private sector. These efforts can be attributed to the level of pollution across the country. The capital, Ulaanbaatar, was ranked in 2016 to be the capital city with the highest air pollution, and the 21st city with the highest level of PM pollution according to the WHO Ambient Air Quality Database (WHO, 2018). Being landlocked between Russia and China is another advantage as electric vehicles manufactured in the countries can be imported with relative ease. In 2017, tax breaks were given to electric vehicles together with exemption from the license plate restriction schemes in the cities and permission to use dedicated bus lanes. To further strengthen the drive for increased EV use, the government is open to partnership with the private sector to install charging infrastructure in private and public premises, and to subsidize the provision of services for electric vehicles.

3.2.5 Thailand

Thailand, a member of the Electric Vehicles Initiative, had 84236 units of electric vehicles in use in 2017, according to the statistics by Thailand Land Transport Department. The country has about 500 charging stations across the country with 96 of the lot being publicly accessible. The EV adoption in the country has been enabled by the development of local EVs, research and development geared towards improved EV components by academic institutions as well as support from the government who have incentivized EV manufacturing sectors with tax waivers and exemptions and subsidized installation of charging infrastructure to achieve their aim of having 690 publicly accessible charging stations and 1.2 million electric vehicles nationwide by 2036 (KPMG, 2018). However, KPMG (2018) evaluates the growth in EV adoption and penetration rate to be low as PHEVs and BEVs hold a share of 0.0008 % of the number of electric vehicles in use. It suggests user-centered incentives and reduced cost of maintaining and operating the required infrastructure for EV use to be lowered to give the adoption of EVs a boost.

3.2.6 China

The Asian country although an emerging economy is a force to reckon with in EV manufacturing and adoption. China accounts for 40 % of the global stock of electric vehicles which surpassed 3 million vehicles in 2017 with 580000 electric car sales made in the year only. China is also home to almost all 366000 units of charging outlets on private fleet and has 213903 publicly accessible chargers (IEA, 2018a). Furthermore, about 45 % of the global automobile industry's planned EV investment and procurement budget (which is more than \$135 billion) will be spent in China (Lienert et al., 2019). The successes of China cannot but be related to the huge promotion of the manufacture and sale of EVs through a combination of government-mandated quotas, credits, incentives and other policies targeting cross-modal electrification. An example of such policies is the "Guiding Opinions of the General Office of the State Council on Accelerating the Construction of New Energy Vehicle Charging Infrastructure" which is geared towards increased industrialization and reduced greenhouse gas emissions in the country. However, there are concerns that the market share of EVs in the country may suffer a sharp fall when the market incentives for EV use are abrogated as planned in 2021 except a new policy system is introduced to keep the market stability (Wang et al., 2019).

3.3 Africa

3.3.1 Ethiopia

Without proffering solutions to the electrical shortages in the country through significant infrastructural investments and grid integration, EV use will not be a choice for Ethiopians. The country, however, is making efforts to build a clean and clear environment while boosting the economy through the "Climate-Resilient Green Economy Strategy" which projects a modal share of 13 % and 2.2 % for hybrid and electric vehicles respectively (EPA, 2011).

3.3.2 Tunisia

While there is no record of EV registration in Tunisia, there are positive signs towards EV use and with a right mix of policies and actions, EV use may receive a boost in the country. The government in its 2018 Finance Act introduced a reduction in tax for the import of hybrid vehicles. The government also introduced an electric bus into its public transport fleet in the capital city in 2018. These are furthered bolstered with the foreign investment for the manufacture of electric vehicle components received by the Tunisian automotive industry.

3.3.3 Nigeria

Except for a DW Network Report (DW, 2018) that estimates Nigeria has about 100 hybrid vehicles in its vehicle mix, there is no record of EV use and no public charging infrastructure in the country. To diversify the economy away from oil dependence, the government is making policies to encourage manufacturing including local vehicle production and assembly but there is no specific EV production strategy. Apart from the high cost of EV and electricity shortfall, EV adoption has a greater barrier in the country. Due to the dependence on oil, the wealth of the high social and political class is majorly built around petroleum products marketing and distribution. The feasibility of a major policy change or action by the government to favor EV adoption and penetration in the country is therefore low as it will lower fuel consumption.

3.4 Middle and South America

3.4.1 Mexico

The demand for all types of EVs is gradually increasing in Mexico as the sales during the first seven months of 2018 were 63.3 % higher than the same period in 2017. However, sales for fully electric vehicles declined for the same period by 12.9 % as 131 all-electric vehicles were sold from January till July of 2017 and this figure decreased during the same period of 2018 to 114.

The first charging stations were opened on January 13, 2015. The current number of EVs charging station in Mexico now is exceeding 1600 stations. Moreover, the charge cost is very low as it costs between \$1 to \$4. The responsible authority Mexico's Comision Federal de Electricidad has signed an agreement with the private sector to develop the existing charging infrastructure.

The governmental strategies to promote EVs are incomplete and incomplete. However, there are some incentives to encourage users to turn to EVs. For instance, there is an exemption from some taxes such as yearly vehicle ownership tax, similarly, the owners are not included in "Hoy No Circula" program which specifies the days when the vehicles can use the road. Many obstacles which limit the spread of EVs are the lack in charging infrastructure especially the capacity of electric grids and charging stations, insufficient government policies and regulations to support EVs in the Mexican market as Mexico produces internal combustion engines and it will be against the local producer interests to import EVs from abroad. One more obstacle is the high cost of owning EV in Mexico (Galan et al., 2016).

3.4.2 Ecuador

The Ecuadorian government encourages citizens to use EVs in order to reduce emissions in the country. For example, it has reduced customs duties and taxes on the EVs as shown in Table 2. Likewise, the government seeks to attract investors to invest in the charging infrastructure for EVs such as Korean companies. Moreover, special tariff system was adopted by the Regulation and Control of Electricity in Ecuador to motivate citizens to turn out to EVs (Vera et al., 2017).

The fleet of the EVs is very small compared to the conventional cars in Ecuador (<1 %) as the statistics show that there are only 240 EVs in the country. The private sector is trying to cope with the new trends of using eco-friendly vehicles like Saucinc (a private bus operator) which signed a contract with BYD in order to change the bus fleet serving the city of Guayaquil into electric buses (20 buses) by March 2019 and installing within the project the first fast charge station. This project has a high level of acceptance among users. Similarly, in the city of Loja, Ecuador the government supported with the purchase of 30 electric taxis based on the request of the local community.

Ecuador has a strong motivation to change to electric transport (Davis, 2016). In Ecuador, it is needed to change from conventional network to smart grid with overall integration in the system and the used software and hardware in order to achieve perceived shift in road transport towards electric mobility (Valenzuela, 2016).

3.4.3 Brazil

Only 1472 EVs were sold during the first six months of 2018 in Brazil. This very low number of EVs share in the country was faced by some governmental strategies to increase it such as reducing the taxes on the mass-producer of EVs by 7 %.

The charging infrastructure is developed and constructed by the private sector as the government has no agenda for the deployment of EVs infrastructure which can be attributed to the recession in the country as well as the effect of oil manufacturer lobby in not supporting EVs. The first two charging stations were opened by CPFL Energia (a private companies' group) which was followed by an agreement to set 30 charging stations within Groups privilege space (Li, 2016).

The former capital city, Rio de Janeiro, needs 2000 EVs charging infrastructure to supply 1 % of EVs penetration to the market by 2025 (Costa et al., 2017a). However, there are no clear governmental policies to identify a business

Table 2 Tax for conventional and EVs in Ecuador (Vera et al., 2017)

Type	Import Tax	VAT	Special Contrib. Tax
Cars	35–40 %	12 %	5–35 %
EVs	0 % (<40000 \$)	None (<35000 \$)	None (<35000\$)

model for EVs or EVs charging infrastructure, similarly for identifying the EVs types, which results in fewer investments in EVs market and repels the investors out of the market (Costa et al., 2017b).

The transport sector in Brazil has the biggest share of greenhouse gas emissions, however, more than 80 % of the electricity production is made using renewable sources. Therefore, shifting to the EVs will help in reducing the CO₂ emission and preserve a better health condition. The private sector and public one is trying to deploy the EVs in different sectors of the country in order to reduce the air pollution and benefits from the low operational and maintenance cost, for instance the local police force of the city of São José dos Campos signed a contract with BYD to use 30 EVs within its fleet in July 2018. Another example is manufacturing the first Brazilian EV which is made completely in Brazil and supposed to be released in the market by 2020.

4 Incentives and augmentation pathways in emerging economies

4.1 Experiences

The countries in the Middle East generally face the effects and impacts of oil-based economies: the crude oil production is an important pillar of the economies, the conventional fuel prices are below the world average, and electricity has only a secondary role in the country's energy mix. These items raise significant bottlenecks in EV market penetration.

Industrialization, rapid technological growth and environmental concerns are the major drivers for the adoption of EVs in the Far East region according to the respondents. However, there are still some barriers slowing the penetration rate of the EV market in most of the countries covered.

Reports from respondents from Africa who are specifically from Ethiopia, Tunisia and Nigeria backed up with secondary data from reports show the electric vehicle adoption and penetration rate in the rapidly urbanizing continent is next to zero. Although South Africa gives a little glimmer of hope having the highest rate of EV adoption with the electric car stock of BEV and PHEV being about 860, the modal share of EVs in the country's fleet is just only about 0.07 % (IEA, 2018). The prohibitive cost of electric vehicles and the lack of charging infrastructure has been a barrier towards its acceptance and use in this region.

The cases of Middle and South America show some duality, where on one side the countries are suffering from negative externalities of road transportation, on the other side motorization and car industry are important pillars of the economies.

4.2 Boosting the EV market

The authors identified four main preconditions as thresholds for reaching remarkable growth in the EV market:

1. available, reliable and accessible electric power sources on a 24/7 basis,
2. the oil and petroleum product dependence of a country's economy should be broken and re-calibrated towards a sustainable way,
3. there should be a political will towards EV market expansion,
4. a valid business model should be worked out, incorporating both the public and private stakeholders.

If these preconditions are fulfilled, the next step is to face the problems and to find proper incentives and other actions to tackle the barriers and bottlenecks of EV market in the emerging economies, see Table 3.

5 Conclusions

The EV market in emerging economies suffers from different barriers and bottlenecks, where some of them are of crucial importance and others are influencing the expansion process.

The initial steps towards the EV market penetration are setting up the supply side (reliable electric power sources and initial charging network), reaching political and broader social acceptance in need for EVs (breaking the oil dependence of economies and turning towards e.g. the EV industry) and working out the operational framework (building valid business model for the EV market and relating services).

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Table 3 Problems and solutions towards EV market penetration in emerging economies

Identified problems	Proposed solutions
Low purchasing power	<ul style="list-style-type: none"> Reducing registration fees Reducing custom fees Reducing annual vehicle taxes Lowering electricity consumer prices for charging EVs
Lack of charging network	<ul style="list-style-type: none"> State/municipality subvention to install new charging stations License for new gas station with an obligation to deploy e-charging service License-fee free permission of installing charging stations Incorporating the EV system into a Smart Grid system
Congestion, pollution	<ul style="list-style-type: none"> Combining different transport policy instruments where EVs have priorities Exemption of EVs from traffic restriction schemes and/or using bus lanes Public procurement of electric vehicles, especially in public transport services
Lack of place for public charging stations	<ul style="list-style-type: none"> Enabling private charging services

The EV market boost is happening first in urban environments, where the existing problems and impacts of road traffic are essential to citizens and decision-makers, and where the current EV technologies offer a real alternative to the conventional vehicles (zero local emission, small travel distances). Private capital investment can have a remarkable role in substituting lacking public financial sources. Nevertheless, supporting technology research and development activities in the economy contributes to a fully or partially independent EV industry.

As generally in most countries there is the initial phase of the EV market expansion, government or municipality incentives are essential for any remarkable growth in the EV market and any cut of incentives in the short term threatens the achievements and the future expectations.

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